REMARKS

Claims 1-24 are rejected in the Action under 35 U.S.C. §112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. For convenience in discussing the rejection, reference is made below to the claim and line numbers identified by the Examiner in the Action.

<u>Claim 1, line 4</u>: Claim 1 has been amended to recite first and second substrates.

<u>Claim 1, lines 10-11</u>: The rejection is not correct because the specification does not require that the reference electrode be active to only oxygen. At page 18, lines 12-19, it is described that "[T]herefore, <u>the reference electrode is either composed of NOx-inactive electrode material</u> or configured so as not to be exposed to NOx. <u>When it is inactive to NOx</u> and active to oxygen, the reference electrode 12 can be installed in the same atmosphere as the NOx sensing electrode 11, or inside the the gas detection chamber 3 as shown in Fig. 1." (Emphasis added). And at page 27, lines 20-25, it is described that "[n]ow, the reference electrode 12 of the NOx sensing cell 11, 12 is installed in a reference duct

23 which leads to the air. In this case, the reference electrode 12 can be active to oxygen only, which means a wider selection of materials for the reference electrode 12." (Emphasis added).

These descriptions clearly indicate that the reference electrode can be active to NOx as well as to oxygen. If the reference electrode is active to oxygen and inactive to NOx, the reference electrode can be put in the gas detection chamber and exposed to the same atmosphere as the NOx sensing electrode. On the other hand, the reference electrode may be active to both oxygen and NOx when the reference electrode is isolated from the atmosphere of the gas to be detected as shown in Fig. 7 (here, the reference electrode is exposed to the atmospheric air).

Notwithstanding that original claim 1 is believed to be proper, claim 1 has been limited to the embodiment where the reference electrode is fixed onto the zirconia solid electrolyte substrate on the side opposite to the side on which the NOx sensing electrode is fixed and the reference electrode is active to at least oxygen. A new claim (claim 25) has been added to the application to recite the embodiment where the reference electrode is fixed onto the zirconia solid electrolyte substrate on the same

side as that on which the NOx sensing electrode is fixed and the reference electrode is active to oxygen and inactive to NOx.

Claim 1, lines 25-26: With respect to the suggestion to define the inorganic porous member as comprising a catalyst, the use of a catalyst for promoting the oxidation of the reducing gas is not essential for the present invention and it is only a preferred embodiment thereof. The inorganic porous member is located between the gas inlet and the gas detection chamber in the present invention. The object is to fill the porous member of the first gas treatment chamber with the oxygen supplied by NOx conversion pumping cell and efficiently oxidize the reducing gases in the gas to be detected which is introduced through the gas inlet. (See page 13, lines 3 - 7, in the present specification).

The porosity of the inorganic porous member is limited in the present invention to achieve the object of the present invention without the inorganic porous member carrying an oxidation catalyst. Specifically, by limiting the porosity to the range of 5 - 40%, the velocity for diffusing the gas to be detected and oxygen into the inorganic porous member becomes better, so that oxygen concentration in the gas treatment chamber is maintained at a high

level and a good response speed to NOx is obtained. The oxygen gases tend to adsorb on the surface of the porous member which comprises inorganic materials such as zeolite, zirconia, alumina or silica as seen in the text, wherein adsorbed oxygen is atomized or electric charge is provided, thus the reducing gas passing through the porous member is effectively oxidized.

Claim 2, lines 2-3: The claim has been amended to remove the parenthetical expression.

Claim 4, line 5: The claim has been amended to insert --a-- before "second".

Claim 4, lines 2-5: Claim 4 has been amended to recite that the first gas treatment chamber is formed in a separate layer from the zirconia solid electrolyte substrates surrounding the gas detection chamber, or surrounding the gas detection chamber and a second gas treatment chamber. This amendment is supported by the structure shown in Fig. 9 and the description in the specification on page 30, line 6, to page 31, line 13. A first gas treatment chamber 5 is separately formed from the gas detection chamber 3 (not including the second gas treatment chamber 4) or the gas detection chamber 3 and the second gas treatment chamber 4 (see

Fig. 9). The first gas treatment chamber 5 communicates through the gas diffusion hole 6 or the porous member in the first zirconia solid electrolyte 1a with the gas detection chamber (not including a second gas treatment chamber 4) or with second gas treatment chamber 4 (see Fig. 9).

<u>Claim 6, line 5</u>: The expression "and/or a compound" has been chanded to -and a compound-. Mullite is a compound of alumina and silica and spinel is a compound of alumina and magnesia.

<u>Claim 9, line 2</u>: The terminology "to be" has been deleted.

<u>Claim 10, line 2</u>: The terminology "to be" has been deleted.

<u>Claim 12, line 2</u>: Claim 12 has been amended. The anode 16 of the oxygen supplying pumping cell is the oxidation catalyst electrode and the oxygen supplying pumping cell is the oxidation catalyst pumping cell as shown in Fig. 8. Namely, these two cells are one and the same.

<u>Claim 15, lines 2-3</u>: The terminology "to be added" has been changed to --of-- as suggested by the Examiner.

<u>Claim 16, line 2</u>: The comments above relating to claim 12 are applicable to claim 16.

<u>Claim 16, last line</u>: Fig. 6 and 10 show the structure of claim 16 in which the cathode is located on a duct communicating with the gas to be detected. The structure of this duct can be applied to any embodiment. By this structure, it is possible to supply oxygen by the oxygen supplying pumping cell even if no oxygen exists in the atmosphere of the gas to be detected. (See page 24, lines 9 - 19, of the specification).

<u>Claim 17, line 3</u>: Claim 17 has been amended to provide proper antecedent basis for the claim terminology.

<u>Claim 19, line 4</u>: Claim 19 has been amended to recite firat and second sibstrates.

<u>Claim 19, lines 10-11</u>: See the comments above relating to the terminology "active to at least oxygen". See also new claim 26.

<u>Claim 19, last paragraph</u>: Claim 19 has been amended to change "while converting NOx in the gas to be detected into NO_2 or NO" to --when NOx in the gas to be detected is converted into NO_2 or NO--.

<u>Claim 22, line 2</u>: "NOx detection cell" in claim 22 has been changed to --NOx sensing cell--.

Claim 23, line 3: "NOx detection cell" in claim 23 has been changed to --NOx sensing cell--.

Claim 23, lines 4-5: Claim 23 has been amended to recite --said first ... substrate-- for consistency with the amendments to claim 1.

Claims 1-24 are rejected in the Action under 35 U.S.C. §103(a) as being unpatentable over DE 19852247 ("DE '247") in view of Japanese Patent No. 11-23526 ("JP '526"). Claims 1-24 are also rejected under 35 U.S.C. §103(a) as being unpatentable over DE '247 in view of Linder et al. (United States Patent No. 4,132,615) ("Linder") or EP 517366 ("EP '366) and Japan '526. The the Office has identified Hasei et al., United States Patent No. 6,319,377 ("Hasei"), as an English language equivalent of DE '247 and Gao et al., United States Patent No. 6,303,011 ("Gao"), as an English language equivalent of JP '526.

With respect to the 35 U.S.C. § 103(a) rejections, claim 1 has been amended to overcome the rejection by limiting the porosity of the porous member to the range of 5 - 40% by volume (see page 13, line 23, claim 5), by reciting that the first gas treatment chamber

is disposed between the gas detection chamber and the gas inlet, and by reciting that the inorganic porous member is loaded <u>only</u> into said first gas treatment chamber (i.e., is not loaded into the gas detection chamber).

The NOx conversion electrode for supplying oxygen is disposed in the gas detection chamber in the present invention and the direction in which oxygen is supplied to the first gas treatment chamber and the direction in which the gas to be detected is supplied to the first gas treatment chamber are opposite to each other. Therefore, it is possible to steadily bring the reducing gases in the gas to be detected into contact with oxygen absorbed on the surface of the porous member and to more efficiently oxidize the reducing gases.

According to the present invention, the porous member is not loaded between the NOx conversion electrode and the NOx sensing electrode, so that a path between the NOx conversion electrode and the NOx sensing electrode is the shortest possible distance and NOx oxidized on the NOx conversion electrode can be measured as NO_2 rapidly and in a more accurate manner.

With respect to DE'247 (Hasei) and JP'526 (Gao), Hasei discloses a device similar to that of the present invention and Gao discloses a porous member carrying an oxidation catalyst 111, which is loaded in a chamber. However, Gao fails to teach a porosity of the porous member. As explained above, the degree of the porosity of the inorganic porous member is important to completely oxidize the reducing gas in the gas to be detected and to obtain a constant level of response. When the porosity of the inorganic porous member is not optimum, such advantages are not obtained.

Hasei and Gao also teach loading the porous member between NOx conversion electrode and NOx sensing electrode. For example:

<u>Hasei et al.</u>

> "When the NOx converting electrode 3a of the oxygen pumping portion and at least the detecting electrode 4a comprising the NOx gas detecting portion are opposed to each other, a porous member 12 is interposed between the NOx converting electrode 3a and at least the detecting electrode 4a to reduce the spacing between the two electrodes so that NOx, as converted by the oxygen pumping portion 3, can be instantly detected by the NOx gas detecting portion." (Column 7, lines 10-18, of U.S. Patent No. 6,319,377).

<u>Gao et al.</u>

> "In a case where the electrode 103a of the oxygen pump 103 and at least the sensing electrode 104 that

forms the NOx gas sensing cell oppose each other, a porous body 112 is placed between the electrode 103a and at least the sensing electrode 104 and the gap between these electrode is reduced, thereby making it possible to immediately sense, by the NOx gas sensing electrode, the NOx gas that has been converted by the oxygen pump 103." (column 9 line 63 to column 10 line 3 in US 6,303,011 which is equivalent of Japan'526).

"Furthermore, by forming an oxidation catalyst in the first chamber 118 and second chamber 123 or filling these chambers with this catalyst, converted NOx gases reach the NOx gas sensing cell without being reduced again, thus making the highly accurate sensing of NOx concentration possible." (Column 11, lines 23 - 28, of U.S. Patent No. 6,303,011).

The location of the porous member results in considerably increasing the path distance between the NOx conversion electrode and the NOx sensing electrode, and NO_2 as oxidized on the NOx conversion electrode is reduced easily to NO again by an equilibrium reaction as shown in Fig. 1.

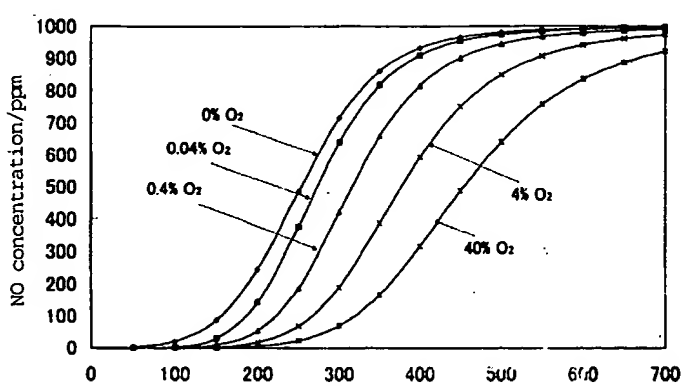

Fig. 1 NO equilibrium concentration in 1000 ppm/NOx

Even if the oxidation catalyst is carried on the porous member, the speed for converting NO_2 to NO is merely restrained and the equilibrium state (NO balance) at the sensor operating temperature is not varied. Contrary to this, the present invention employing the afore-mentioned structure makes it possible to improve the NOx detecting accuracy.

With respect to DE'247 (Hasei) and Linder, Linder teaches locating a catalyst 16 before a solid electrolyte sensor to react with the reducing gas and bring a sample gas to equilibrium. Linder does not teach the porosity of the catalyst 16 or an oxygen pumping cell for supplying oxygen to the catalyst 16.

The Office suggests that an oxidation catalyst reactive to the reducing gas may be applied to the structure of Hasei in view of Linder. Even if this is assumed to be correct, the porosity of the porous member is not taught by the prior art. Moreover, Hasei teaches locating the porous member between NOx converting electrode and the detecting electrode. This is contrary to the structure of the present invention.

With respect to DE'247 (Hasei) and EP'366, EP'366 discloses a structure wherein the oxidation catalyst 17 for oxidizing the interference reducing gas is disposed before the nonselective oxides of nitrogen sensor. However, EP'366 does not disclose the porosity of the oxidation catalyst 17. In EP'366 the direction wherein the gas to be detected flows into the oxidation catalyst means 17 is the same direction wherein the oxygen flows into the oxidation catalyst means 17, which oxygen is supplied to the electrochemical cell 10. (In Fig. 1 from right to left).

With respect to Claim 11, the Office suggests that since the metal catalyst is a conductor and is in contact with the pumping electrode 103 in the treatment chamber, it will inherently act as an oxidation catalyst electrode. According to the amended claim 11, the oxidation catalyst electrode comprises the oxygen-ion conductive solid electrolyte. This is distinguishable from the references. In Claim 11, since the porous member comprises an oxygen-ion conductive material and is used as an anode, an active oxygen is supplied from the whole of the porous member and the reducing gas which is diffused in the oxidation catalyst electrode is oxidized more efficiently. In this structure, the oxidation

performance is improved as compared with the art where the oxygen supplied by the oxygen pumping cell is supplied to the porous member after it is changed to molecular oxygen.

Gao discloses that:

> "If the porous body 112 is a material having a high electrical insulation, the signal output of the NOx gas sensing can be extracted without being influenced by the voltage that drives the oxygen pump 103." (Column 10, lines 5 - 8, of U.S. Patent No. 6,303,011).

Linder and DE'247 teach using aluminum oxide (Column 2, lines 50 - 62, in Linder; Column 4, lines 3 - 8, in DE'247) or spinel (Column 4, lines 3 - 8, in DE'247). In the case that the porous member comprises the electrical insulation material or the electronic conductive material, the advantages of the present invention can not be achieved. It is noted that the porous member, which comprise the oxygen-ion conductive solid electrolyte, is not disclosed or suggested in any references and the invention defined by amended claim 11 is patentably distinct from the prior art.

The prior art, for the foregoing reasons, fails to support a prima facie case of obviousness of the claims of the application, particularly as amended, and removal of the 35 U.S.C. § 103(a)

grounds of rejection is believed to be in order and is respectfully solicited.

The foregoing is believed to be a complete and proper response to the Office Action dated August 1, 2003, and is believed to place this application in condition for allowance. If, however, minor issues remain that can be resolved by means of a telephone interview, the Examiner is respectfully requested to contact the undersigned attorney at the telephone number indicated below.

In the event that this paper is not considered to be timely filed, applicants hereby petition for an appropriate extension of time. The fee for any such extension may be charged to our Deposit Account No. 111833.

In the event any additional fees are required, please also charge our Deposit Account No. 111833.

Respectfully submitted,
KUBOVCIK & KUBOVCIK

Ronald J. Kubovcik
Reg. No. 25,401

Atty. Case No. KUW-044
The Farragut Building
Suite 710
900 17th Street, N.W.

Washington, D.C. 20006
Tel: (202) 887-9023
Fax: (202) 887-9093
RJK/cfm